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PAPERS ON INSECTS AFFECTING STORED PRODUCTS.

CARBON TETRACHLORID AS A SUBSTITUTE
FOR CARBON BISULPHID IN FUMIGA-
TION AGAINST INSECTS.

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TRUCK CROP AND STORED PRODUCT INSECT INVESTIGATIONS.

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CONTENTS.

	Page.
Introduction	53
Experiments at Washington, D. C.	54
Experiments at Baltimore, Md.	55
Comparative cost of carbon bisulphid and carbon tetrachlorid	56
Conclusions	57

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INTRODUCTION.

A representative of a chemical company in Baltimore, Md., suggested to the senior writer as early as 1905 the use of carbon tetrachlorid (CCl_4) as a possible substitute for carbon bisulphid (CS_2), since he tetrachlorid is known to be noninflammable. A sample was kindly furnished and was thoroughly tested in the open and found, as claimed, to be noninflammable. No opportunity, however, was afforded at that time to make a detailed series of tests of its insecticidal properties.

A druggist of Washington, D. C., also suggested the substitution of this chemical for carbon bisulphid, and as others had made similar suggestions a series of experiments was begun on a small scale at Washington, D. C., under the senior author's direction, by the junior author and by Mr. D. K. McMillan.

Carbon tetrachlorid, when pure, is a thin, transparent, colorless, oily fluid, with a pungent, aromatic odor—not powerful, however, as in the case of carbon bisulphid, and not nearly so disagreeable. It is manufactured by the combination, in a heated tube, of the vapors of carbon bisulphid and chlorine. It has a specific gravity about one-third greater than carbon bisulphid, and is similar in other properties, with the exception of being noninflammable.

There are records of experiments made with this chemical as a fumigant for nursery trees in 1908, but tests for stored products affected with insects were made more recently. One of the former records is by Dr. W. E. Britton,¹ who states that carbon tetrachlorid was used at rates of from 1 to 8 ounces in a fumigating box containing 10 cubic feet of space, the fumigating period varying from 2 to 6 hours. All scales were killed, and no trees were injured, where

¹ Journ. Econ. Ent., vol. 1, p. 111, 1908.

30 ounces or less of the liquid to 100 cubic feet were used, with a fumigating period of two hours. Greater quantities of the liquid caused injury and killed some of the trees. In these experiments the liquid was also volatilized by means of heated pans. In conclusion Dr. Britton states that in his experience it proved noninflammable, but that it is not very poisonous to the *higher* forms of animal life.

This compound seems first to have been employed as a substitute for carbon bisulphid as a fumigant for structures containing grain and similar products infested by insects by Prof. Albert P. Morse, Wellesley, Mass., who published an account of the result in February, 1910.¹ He used it against *Attagenus*, presumably *A. piceus*, as this is the only species of the genus commonly found in the United States. It was employed in a standard museum case which closed tightly, and the strength was 1 quart to 50 cubic feet, which Prof. Morse claims is only twice the strength at which carbon bisulphid is used. In practical use, in perfectly tight inclosures, 1 pound of pure carbon bisulphid to 1,000 cubic feet of space will destroy some insects, but perhaps not the dermestids which affect stored products.

EXPERIMENTS AT WASHINGTON, D. C.

Experiment No. 1.—July 27, 1908, a quantity of rye was subjected to treatment with carbon tetrachlorid at the rate of 1½ pounds to each 1,000 cubic feet. The grain, which was infested with the rice weevil (*Calandra oryza* L.), the saw-toothed grain beetle (*Silvanus surinamensis* L.), and a smaller grain beetle (*Læmophloeus minutus* Oliv.), was closed and left for 48 hours. It was then opened and the insects of the different species were found to be living and in good condition. The experiment was therefore a failure.

Experiment No. 2.—A similar quantity of the same grain with the same insects was fumigated 48 hours with carbon tetrachlorid at the rate of 3 pounds to 1,000 cubic feet. At the end of this time all the beetles present were alive and in good condition.

In these two experiments a closed tin receptacle with air-tight top was used and quantities of the chemical greater than the ordinary amounts of carbon bisulphid for air-tight inclosures were applied. It seems, therefore, that the insecticidal quality of this liquid, if present, is decidedly less than that of carbon bisulphid.

Experiment No. 3.—October 6, 1908, a quantity of grain practically equivalent to that used in previous tests was subjected to treatment with carbon tetrachlorid at the rate of 6 pounds to 1,000 cubic feet, or double the amount used in experiment No. 2. Living specimens of the confused flour beetle (*Tribolium confusum* Duv.), with a few rust-red flour beetles (*T. navale* Fab.), *Silvanus surinamensis* L., *Calandra oryza* L., and *C. granaria* L., the cadelle (*Tene-*

¹ Journ. Econ. Ent., vol. 3, p. 104, 1910.

broides mauritanicus L.) present as larva, and the larva of the Indian-meal moth (*Plodia interpunctella* Hbn.) and of the Mediterranean flour moth (*Ephestia kuehniella* Zell.) were included, as well as adults of the related fig moth (*Ephestia cautella* Walk.). The flour-moth and the fig-moth larvæ were working in a small mass of bran and flour well matted with silk. The quantity of material was about 1 pound, loosely inclosed in a cheesecloth bag.

The fumigating box was closed at 3 p. m. October 6, and calked around the edges of the lid with cotton wadding. After being closed for half an hour no escape of fumes could be noticed. The box was opened at 3.30 p. m. October 7. The fumes of the tetrachlorid were very strong; hence the escape of fumes must have been slight.

The material was all taken out and exposed in the fresh air in the outside insectary until the following day, but immediate superficial examination showed all insects motionless except the larvæ of *Tenebroides*, which moved slowly when touched. Final examination showed: Flour-moth adults dead; a few examples of their larvæ dead, but the greater number living. The *Tenebroides* larvæ were unharmed. The flour and grain beetles and the two grain weevils were nearly all living but moving their antennæ or legs very feebly, seeming to be in a paralyzed condition. Numerous examples were placed in a vial with a small amount of flour and stoppered with cotton. On October 16 a few of these were still moving legs or antennæ slightly, but seemed paralyzed and not able to recover.

Experiment No. 4.—This was a repetition of No. 3 in most of the details, except that 10 pounds to 1,000 cubic feet were used. The four-spotted bean weevil (*Pachymerus quadrimaculatus* Fab.) was included in a small sack of beans. About half the quantity of material containing the flour-moth larvæ was taken.

The box was closed at 3 p. m. and carefully calked with cotton. October 17, at 3 p. m., or 24 hours later, the box was opened and the contents freely exposed to the air. All of the bean weevils and other beetles seemed to be dead, but the cadelle larvæ moved slightly when touched, though they were not active. Forty-eight hours after opening all were dead except a few larvæ of *Tenebroides*.

If the material were a cheap product it might prove a substitute for carbon bisulphid if used in strengths greater than 10 pounds to 1,000 cubic feet. Possibly fumigation for a longer time might increase the effectiveness, but it is most obviously not so fatal as is carbon bisulphid.

EXPERIMENTS AT BALTIMORE, MD.

Experiment No. 5.—October 25, 1910, a quantity of shelled corn stored in a new concrete elevator in Baltimore, Md., was reported by Dr. J. W. T. Duvel, of the Bureau of Plant Industry, to be quite badly attacked by weevils which had worked to such an extent that

the temperature had increased from 76° to 90° F. An examination of the corn showed extensive damage by the granary weevil (*Calandra granaria* L.), while *Cænocorse ratzeburgi* Wissm. and *Læmophloeus minutus* Oliv. were also present in some numbers. Since the bin was of concrete and capable of being tightly closed, the opportunity was taken by the junior author for a thorough trial of carbon tetrachlorid as a fumigant. The bin was a trifle over 6 feet square and 75 feet in depth, giving a capacity of approximately 3,000 cubic feet. A dose of 15 pounds of tetrachlorid was poured over the grain from the top of the bin, the grain, 1,300 bushels in all, extending nearly to the top of the bin. The bin was closed and left for four days. October 29, when opened, a slight odor of gas remained. The grain was run over a No. 8 screen and the estimate of mortality made from the insects found. No living *Cænocorse* or *Silvanus* were observed. About 50 to 60 per cent of the *Calandras* were killed, the remainder being very stupid after the screening and thorough airing.

The weevils in this case were left in separate jars for a number of days afterwards in order to ascertain if recovery took place later, but no difference in the number killed was noted.

Experiment No. 6.—A second fumigation was applied early in November, the fumigant being used in the same bin, but at the rate of 9 pounds to 1,000 cubic feet. At this rate the poison was applied in five layers, 250 bushels of corn being run into the bin between applications of 5 pounds each of carbon tetrachlorid. The bin was closed 5 days, then the corn was run over a No. 6 screen, and specimens of weevils collected from the screenings. In this treatment about 90 per cent of the weevils, which by this time consisted almost entirely of *Calandra granaria*, were killed.

Specimens were exposed for recovery but failed to do so. The odor of carbon tetrachlorid was strongly noticeable while the corn was being screened and the gas was apparently well distributed through the corn. This experiment would indicate that carbon tetrachlorid is much less valuable as an insecticide than the bisulphid. The tetrachlorid used was purchased in the open market in Baltimore, at a cost of 28 cents a pound.

COMPARATIVE COST OF CARBON TETRACHLORID AND CARBON BISULPHID.

Inquiry of the Bureau of Chemistry in regard to the comparative cost of these chemicals elicited the reply that the contract prices for supplies for the Department of Agriculture for the year ending June 30, 1909, quoted carbon bisulphid at \$0.11 a pound (quality not designated) to \$0.28 a pound (chemically pure), while carbon tetrachlorid was quoted from \$0.45 to \$1 a pound. Prices in the Oil, Paint and

Drug Reporter December 1, 1908, were carbon bisulphid 5 to 7 cents a pound, and carbon tetrachlorid $9\frac{1}{2}$ to 16 cents a pound wholesale. These last quotations represent prices in bulk, and variation is evidently dependent upon the quantity desired.

CONCLUSIONS.

For all practical purposes it will readily be seen that carbon tetrachlorid at the rate of 28 cents a pound costs fully three or four times as much as carbon bisulphid and, in the case of purchase at retail drug stores, probably on an average of two to three times as much. Considering the strength at which it is to be used, it is very obvious that this chemical, unless it can be manufactured at a much lower price, can not be as economically employed as a remedy for insects injurious to stored products in warehouses, mills, or in any other depository, but might be used for choice seeds or in office rooms and dwellings, which can be very tightly closed and where the use of inflammable materials is prohibited or is for other reasons undesirable.